MEDITERRANEAN SILVOARABLE SYSTEMS FOR FEED AND FUEL: THE AGROFORCES PROJECT (AGROFORESTRY FOR CARBON SEQUESTRATION AND ECOSYSTEM SERVICES)

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Abstract

In a silvoarable systems designed for Mediterranean lowlands with water availability, poplar SRF (Short Rotation Forestry) for biomass production has been intercropped with forage species. In this study, we want to investigate poplar and forage crops suitability to alley-cropping, to assess soil carbon balance, to assess the tree-presence effect in competing for light, to set-up remote sensing techniques with UAVs (Unmanned Aerial Vehicles). Starting from 2018, we will collect data on forage and SRF poplar biomass production. The carbon balance will be calculated by the difference between carbon inputs (aboveground and belowground biomass) and carbon outputs (soil CO_2 efflux measurements). Competition for light will be studied taking hemispherical photographs according to a regular grid, to design maps of transmittance. Starting from emergency stage, we will perform flights with a drone in order to get multispectral images to study the canopies development, selecting the better performing vegetation indexes.

Keywords: silvoarable systems; forage crops; short-rotation forestry; poplar; shade tolerance; carbon balance

Introduction

In the last sixty years, trees have been progressively removed from arable lands because they were seen as an obstacle to productivity, even if they provide ecosystem services which can ensure soil fertility and soil carbon storage in the long term, coping with the goal of sustainable intensification (Quinkenstein et al. 2009). Silvoarable systems bring back trees into croplands, being low-input strategies which can improve nutrients and water cycles, reduce soil erosion and fertility loss, contributing to carbon sequestration. In the case of alley-cropping, herbaceous crops are grown within tree rows (Gruenewald et al. 2007). Innovative alley-cropping systems could be attractive to farmers if designed for bioenergy feedstock production together with forage production, thus providing a diversified income. In Mediterranean lowlands, where water is not a limitant factor, poplar SRF (Short Rotation Forestry) for biomass production could be intercropped with perennial forage species under rainfed conditions. The candidate herbaceous species should be shade-tolerant and overcome competition with trees by taking advantage of the inter-cropping facilitations such as evapotranspiration decrease (Pang et al. 2017).

Alternative land uses such as alley-cropping systems are considered as management practices that conserve and potentially increase soil carbon stocks (Shrestha et al. 2016). Thus, pushing on finding evidences that agroforestry could ensure not only a diversified income but also an economical return for farmers in terms of land value in the long term. Based on this, studying the C cycle dynamics in silvoarable systems as well as soil quality and agricultural GHG emissions should become a priority for researchers in present days.

General objectives

In this research, we want to assess the productivity and the carbon storage potential of several tree-crop combinations suited for agroforestry systems.

Specific objectives

In particular, we want: (i) to investigate poplar and forage crops suitability to alley-cropping, measuring yield and biomass quality for both; (ii) to assess soil carbon balance on different tree-crop combinations; (iii) to assess the tree-presence effect in terms of competition for resources such as light and nutrients. In addition, we want to set-up remote sensing techniques with UAVs (Unmanned Aerial Vehicles), aiming to collect data (e.g. vegetation cover indexes) for implementing GIS-based assessment of the whole agroforestry system.

Materials and methods

In a former poplar SRF plantation, four rows out of five were destroyed in order to have 13,5 m wide per 30 m long plots in the alleys (Figure 1). Plots were sown with two perennial grasses (*Panicum virgatum* L. and *Dactylis glomerata* L.), two perennial legumes (*Medicago sativa* L. and *Hedysarum coronarium* L.) and the two mixtures *P. virgatum* and *H. coronarium*, *D. glomerata* and *M. sativa*. Each forage system was replicated three times in a randomized blocks design. The open field controls were established in 2.5 x 6 m plots outside the alleys, in which the six forage systems were replicated three times. Moreover, five former poplar SRF rows were left with the previous layout, with a density of 7400 plants per hectare.

Starting from the 2018, we will collect data on forage biomass production at each harvest time and we will measure biometric parameters. Poplar SRF will be managed according to a two-year cutting cycle both in the alley system and in the control stand (Nassi o Di Nasso 2010).

The carbon balance will be calculated by the difference between carbon inputs and carbon outputs (Heinemeyer et al. 2012). Carbon inputs will be assessed measuring poplar litter, biomass residuals after mowing and belowground biomass (roots and rhizomes). Carbon outputs will be measured via soil CO_2 efflux measurements. We will apply the chamber method, in which an infra-red gas analyzer (IRGA) with a closed chamber will be placed on a PVC collar fixed in the soil. A PVC collar alone will measure total soil respiration, while the former PVC collar inserted in a PVC cylinder for excluding roots will measure heterotrophic respiration. The chamber method will be applied on three forage systems for three positions, varying according to the distance from the poplar row. Together with flux measurements, soil temperature and soil water content will be recorded (Lai et al. 2017).

Competition for light will be studied on three alfalfa varieties, taking hemispherical photographs in the understory according to a regular grid, to design maps of transmittance (Chianucci et al. 2013).

Monthly, starting from emergency stage, we will perform a flight with a drone in order to get multispectral images to study the canopies development, selecting the better performing vegetation indexes.

Figure 1: Plots within poplar SRF rows at the end of summer, after rotary harrowing and before sowing. Poplar stems are 6 months old, while the whole poplar stand is 8 years old. Stumps distance is 0.5 m within the row.

Expected results

We want to assess the productivity of forage systems in agroforestry, studying their adaptability to shading and competition for water and nutrient.

From this field experiment we expect to obtain a series of evidences about sustainability of alley cropping systems especially in terms of soil carbon storage. We expect to build datasets on crops' growth with remote sensing and to prove the economical feasibility and convenience of agroforestry systems.

References

Chianucci F Cutini A (2013) Estimation of canopy properties in deciduous forests with digital hemispherical and cover photography. Agr Forest Meteorol 168: 130-139.

Gruenewald H Brandt BKV Schneider U Bensa O Kendziab G Huttl RF (2007) Agroforestry systems for the production of woody biomass for energy transformation purposes. Ecol Eng 29: 319-328.

Heinemeyer A Tortorella D Petrovicova B Gelsomino A (2012) Partitioning of soil CO2 flux components in a temperate grassland ecosystem. Eur J Soil Sci 63: 249-260.

Lai R Arca P Lagomarsino A Cappai C Seddaiu G Demurtas CE Roggero PP (2017) Ecological benefits of the alley cropping agroforestry system in sensitive regions of Europe. Catena 151: 202-212.

Nassi o di Nasso N Guidi W Ragaglini G Tozzini C Bonari E (2010) Biomass production and energy balance of a 12-year-old short-rotation coppice poplar stand under different cutting cycles. Gcb Bioenergy 2: 89–97.

Pang K Van Sambeek JW Navarrete-Tindall NE Lin CH Jose S Garrett HE (2017) Responses of legumes and grasses to non-, moderate, and dense shade in Missouri, USA. I. Forage yield and its species-level plasticity. Agroforest Syst DOI 10.1007/s10457-017-0067-8.

Quinkenstein A Wollecke J Bohm C Gruenewald H Freese D Schneider BU Huttl RF (2009) Ecological benefits of the alley cropping agroforestry system in sensitive regions of Europe. Environ Sci Pol 12: 1112-1121.

Shrestha P Seiler JR Strahm BD Sucre EB Leggett ZH (2016) Soil CO2 Efflux and Root Productivity in a Switchgrass and Loblolly Pine Intercropping System. Forests 7: 221 DOI 10.3390/f7100221.